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Reduced Positive Affect on Days With Stress Exposure Predicts Depression, Anxiety Disorders, and Low Trait Positive Affect 7 Years Later

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Positive emotions serve important functions for mental health. Susceptibility to reduced positive emotions in the context of stress may increase risk for poor mental health outcomes, including anxiety and depressive disorders and low overall levels of positive emotion. In an 8-day daily diary study within a larger panel study ($N = 1,517$), we tested whether degree of reduction in time spent experiencing positive affect on days of stress exposure predicted lower levels of positive affect and elevated risk for major depressive and anxiety disorders (generalized anxiety disorder or panic disorder) 7 years later. Bayesian multilevel structural equation modeling controlling for overall levels of affect, stress exposure, leisure time, sex, age, and past year diagnoses of depression and anxiety disorders was conducted. Participants, on average, reported less time experiencing positive affect on days with stressors compared to days without stressors. In addition, participants varied in the extent to which their time spent experiencing positive affect differed across days with and without stressors. Those who reported an especially reduced proportion of the day experiencing positive affect on days with stressors also experienced lower positive affect and greater risk for major depressive disorder and anxiety disorders 7 years later. These prospective associations suggest that between-person differences in the within-person association between stress and positive emotions have implications for mental health years later. The efficacy of preventive interventions could be improved by fostering resilience of positive emotions during common stressful events.

General Scientific Summary
Positive emotions may promote mental health, yet they are depleted during exposure to stress. In an experience sampling study, susceptibility to lowered positive emotions on days with stressors was associated with low positive affect and depression and anxiety disorders 7 years later.

Keywords: stress, positive affect, depression, anxiety, experience sampling

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Stress is a long-recognized risk factor for psychopathology, yet many people who experience even extreme stress do not develop mental health problems (e.g., Pietrzak & Cook, 2013). Research on emotional experiences in the face of stress may inform models of risk toward psychopathology. For example, experience sampling studies have linked susceptibility to heightened negative emotion during naturalistic stress with future depression (Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013; Parris, Cohen, & Laurenceau, 2011) and anxiety (Charles et al., 2013). Depression and anxiety are also associated with greater negative emotional responses to laboratory stressors (e.g., Carthy, Horesh, Apter, & Gross, 2010; Guhn, Sterzer, Haack, & Köhler, 2018). Susceptibility to heightened negative emotion during stress may contribute to the frequency and intensity of negative emotions, as well as the perception that negative emotions are difficult to regulate. Accordingly, negative emotional stress reactivity features in etiological models of depression (Hammen, 2005) and anxiety disorders (Newman, Llera, Erickson, Przeworski, & Castonguay, 2013), conditions characterized by excesses of and difficulty regulating negative emotions.

Positive emotions also serve important functions for mental health. For example, the broaden-and-build theory states that positive emotions widen the scope of thought and attention (Fredrickson, 2001). Positive emotions may therefore protect against psychopathology by curtailing perseverative thought patterns such as

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rumination and worry. Indeed, a positive emotion intervention reduced worry among participants with generalized anxiety disorder (GAD; LaFreniere & Newman, 2019), and positive emotions predicted later mindfulness (Brockman, Ciarrochi, Parker, & Kashdan, 2017) and positive reappraisal (Pavani, Le Vigouroux, Kop, Congard, & Dauvier, 2016) among healthy participants. Positive emotions are also theorized to increase behavioral flexibility (Fredrickson, 2001) and approach toward rewards (Lang & Bradley, 2013). Thus, behaviorally, positive emotions could protect against the excessive avoidance central to depression and anxiety (e.g., Barlow, Allen, & Choate, 2004). Supporting this hypothesis, positive emotions predicted lower avoidance among anxious participants (Chow et al., 2017; Trew & Alden, 2012). Finally, positive emotions are thought to help cultivate social relationships (Fredrickson, 2001), which reduce risk for emotional disorders (e.g., Jacobson, Lord, & Newman, 2017; Jacobson & Newman, 2016). Importantly, positive emotions and their concomitants have reciprocal associations (e.g., Fredrickson & Joiner, 2002; Pavani et al., 2016), leading some to propose that positive emotions trigger "upward spirals" of mental health (Garland et al., 2010). Accordingly, low levels of positive emotions are a long-recognized risk factor for depression (Clark & Watson, 1991), and increasing research has also linked low levels (Khazanov & Ruscio, 2016) and greater instability (Houben, Van Den Noortgate, & Kuppens, 2015) of positive emotions to both depression and anxiety. Therefore, studying positive emotions in the context of stress could help explain the development of depression and anxiety.

In fact, experience sampling studies have documented concurrent and lagged associations between daily stressors and lowered positive emotion (Eldahan et al., 2016; van Eck, Nicolson, & Berkhof, 1998). Positive emotions also decrease during laboratory stress (Williams, Cribbet, Rau, Gunn, & Czajkowski, 2013) and negative life events (Folkman, 1997). Notably, stress is also associated with reduced subjective and physiological responding to positive emotion-eliciting stimuli (Berenbaum & Connelly, 1993; Lapate et al., 2014), suggesting that the association between stress and positive emotion is due to a true reduction in positive emotions, rather than a lack of opportunities for pleasurable experiences. Beyond positive emotions, several other reward-related processes are also downregulated during stress, including appetite (Reichenberger et al., 2018) and neural reward responding (Kumar et al., 2014). Thus, just as negative emotions are heightened, positive emotions and a host of processes that may contribute to positive emotions are lowered in the face of stress.

Between-person differences in the within-person association between stress and positive emotions have also been associated with psychopathology. Persons reporting family histories of depression were most susceptible to diminished enjoyment of daily activities and happy film clips following stress exposure (Berenbaum & Connelly, 1993). Daily diary studies have also documented especially depleted positive emotions on stressful event days among participants with past depression (O'Hara, Armeli, Boynton, & Tennen, 2014) and concurrently elevated depression symptoms (Tolpin, Cohen, Gunthert, & Farrehi, 2006). Higher positive emotion during a laboratory stressor predicted greater trait resilience (Corral-Frías, Nadel, Fellous, & Jacobs, 2016), and higher positive emotion during bereavement was associated with a less pronounced and prolonged course of distress (Bonanno & Keltner, 1997; Folkman, 1997). Beyond lowered positive emotion, greater stress-related downregulation of behavioral and neural reward sensitivity has also been associated with genetic indicators of stress vulnerability (Bogdan, Santesso, Fagerness, Perlis, & Pizzagalli, 2011). Thus, research from diverse literatures has linked susceptibility to lowered state positive emotion, as well as downregulation of a range of reward-related processes, in the context of stress to concurrent and retrospective indicators of risk for psychopathology. Experiencing especially diminished positive emotions during stress may therefore deplete cognitive, behavioral, and social resources for mental health.

Beyond cross-sectional and retrospective studies, prospective experience sampling investigations have found that heightened susceptibility to reduced positive emotions on days with stressful events predicted depressive symptoms across lags of 2 (O'Neill, Cohen, Tolpin, & Gunthert, 2004), 12 (Ong & Burrow, 2018), and 18 months (Zhaoyang, Scott, Smyth, Kang, & Sliwinski, 2020). These studies provide evidence for susceptibility to lowered positive emotions during stress as a risk factor for depression, yet they are limited because they relied on relatively small samples and lacked diagnostic assessments of major depressive disorder (MDD). Moreover, because low positive emotions are also implicated in anxiety (Khazanov & Ruscio, 2016), and positive emotions may engender future positive emotions through reciprocal links with psychological resources (Garland et al., 2010), examining associations between diminished positive emotions in the context of stress and future anxiety disorders and future levels of positive emotion is also warranted.

The present study tested whether susceptibility to lowered positive emotions in the context of daily stress predicted depression, anxiety disorders, and low trait positive affect approximately 7 years later in a large community sample. Susceptibility to lowered positive emotions in the context of stress was indexed by the difference in the amount of time participants experienced positive affect on days with versus without stressful events. Seven-year outcomes included positive affect experienced over a 30-day period, as well as the presence versus absence of MDD and presence versus absence of an anxiety disorder (GAD or panic disorder [PD]). Given that some models have linked low positive affect more strongly to depression than to anxiety disorders such as GAD and PD (e.g., tripartite model; Clark & Watson, 1991), we analyzed these disorder types separately to test whether susceptibility to lowered positive emotions in the context of stress had common (e.g., Khazanov & Ruscio, 2016) or unique associations with anxiety and depression. We hypothesized that stronger negative within-person associations between daily stress and time experiencing positive affect would predict lower future positive affect and diagnosis of depression and anxiety disorders 7 years later.

Method

Participants

Participants were members of the National Study of Daily Experiences (NSDE) project of the Midlife in the United States (MIDUS) study (Ryff et al., 2019; Ryff & Almeida, 2017). MIDUS includes three waves of interviews and questionnaires administered 9 years apart, and NSDE includes 8-day bursts of daily telephone interviews completed approximately 1.5 years after each of the first and second MIDUS waves. Daily positive

emotion assessments were only completed during the second burst within NSDE. Therefore, the sample for the present study consisted of all 1,517 participants who participated in second wave of NSDE (NSDE II) and the third wave of MIDUS (MIDUS III). Of these participants, 847 (55.8%) were women, and 1,393 (91.8%) identified their race as White. The average age at NSDE II was 57.11 years (SD = 11.30).

Procedure

During the second wave of MIDUS (MIDUS II), participants completed a diagnostic interview assessing MDD, GAD, and PD. Participants then completed NSDE II an average of 1.80 years (SD = 1.16) later. During NSDE II, participants received phone calls from researchers once daily for 8 consecutive days. Phone calls were conducted during the daytime (68.2%) or the evening (31.8%). During phone calls, participants completed the Daily Interview of Stressful Events (DISE; Almeida, Wethington, & Kessler, 2002), which asks about the occurrence of common stressful events in the past 24 hr (on the first sampling day) or since the preceding phone call (on subsequent days). Participants also completed measures of daily activities and positive and negative affect, in which they were asked how much of the time on the day of the phone call they felt each of 12 emotions. Thus, stress and affect were measured concurrently, with the time in which a stressor could occur extending slightly before the time frame of emotion reporting. Participants completed MIDUS III an average of 7.33 years (SD = 1.20) after NSDE II. MIDUS III included a telephone call with a psychiatric diagnostic interview and a mailed survey packet including a measure of affect experienced in the past 30 days.

Measures

Stressful events. Stressful events were measured during NSDE II using the DISE (Almeida et al., 2002). The DISE asks about the occurrence of six common events that most people find stressful on a given day. Respondents could also report on any other event they experienced that most people would find stressful. The DISE also assesses characteristics of each stressful event reported (e.g., "How stressful was this event for you?", "Is the issue resolved?"). Consistent with prior use of the DISE (e.g., Charles et al., 2013) and to avoid confounding objective stress exposure with subjective cognitive or emotional responses, analyses treated the presence versus absence of any stressful event (regardless of subjective stressfulness or resolution ratings) on a given day as a binary variable. Stressful events were reported on 40.3% of sampling days. Please see Table 1 for detailed descriptive statistics on stressful events.

Daily leisure time. Daily leisure time in hours was assessed each day during NSDE II with the question, "How much time did you spend on leisure?"

Affect. Affect was measured during NSDE II and MIDUS III using the scale developed by Mroczek and Kolarz (1998). Participants were asked how much of the time during a specified period they felt each of 12 emotions, on a scale ranging from 0 (*none of the time*) to 4 (*all of the time*). Positive emotions included (a) in good spirits, (b) cheerful, (c) extremely happy, (d) calm and peaceful, (e) satisfied, and (f) full of life. Negative emotions included (a) restless or fidgety, (b) nervous, (c) worthless, (d) so sad nothing could cheer you up, (e) everything was an effort, and (f) hopeless. The time periods for emotion reporting were different during NSDE II and MIDUS III and are described below. Joshanloo (2017) found evidence for factorial and criterion validity when the affect scale was administered during MIDUS III.

NSDE II assessment of affect. Each day during NSDE II, participants reported how much of the time during the day they felt each emotion on the scale by Mroczek and Kolarz (1998). Reliability of the positive affect items, calculated using multilevel coefficient alpha (Geldhof, Preacher, & Zyphur, 2014), was .78 within persons and .94 between persons. Reliability of the negative affect items was .56 within persons and .80 between persons. Lower within-person reliability compared to between-person reliability indicates that emotions within each subscale covaried with each other less across day-to-day fluctuations than they did in person-to-person differences.

MIDUS III assessment of positive affect. During MIDUS III, participants indicated how much of the time during the past 30 days they felt each positive emotion on the scale by Mroczek and Kolarz (1998). Cronbach's alpha was .91.

Anxiety and depressive disorders. Anxiety and depressive disorders were diagnosed during MIDUS II and MIDUS III using the Comprehensive International Diagnostic Interview-Short Form (CIDI-SF; Kessler, Andrews, Mroczek, Ustun, & Wittchen, 1998). The CIDI-SF assessed whether, in the past 12 months, respondents met criteria for MDD, PD, and GAD as defined in the *Diagnostic and Statistical Manual of Mental Disorders*, 3rd ed., rev. (American Psychiatric Association, 1987). The CIDI-SF has excellent interrater reliability, sensitivity, and specificity for each disorder (Kessler et al., 1998). We treated diagnosis of MDD and diagnosis of an anxiety disorder (either GAD or PD) as separate binary variables.

Data Analyses

General strategy. Models were fit using multilevel structural equation modeling (MSEM) in Mplus 8 (Muthén & Muthén, 2017) via the *R* package MplusAutomation (Hallquist & Wiley, 2018). As in multilevel modeling, MSEM estimates associations between repeatedly measured variables (e.g., stress reported on a given day predicting time experiencing positive affect on the same day). MSEM accommodates random intercepts that represent differences in the overall level of repeatedly measured variables across persons (e.g., overall levels of positive affect across the 8-day sampling period), as well as random slopes that represent differences in the association between repeatedly measured variables across persons (e.g., an especially strong association between daily stress and time experiencing positive affect for a given person).

In MSEM, fixed effects representing sample-pooled associations between repeatedly measured variables are represented on the *within-person* level of the model, and random intercepts and slopes representing individual differences in repeatedly measured variables and their associations are represented on the *between-person* level of the model. Random effects on the between-person level can be modeled as predictors of individual difference outcomes of interest. For the present study, a random slope for the association between stress and time spent experiencing positive affect on the same day can be considered an indicator of susceptibility to lowered positive affect in the context of stress. This

Table 1
Daily Stressful Event Frequencies

Variable	Endorsed *n* (%)
Any stressful event	4,587 (40.3)
Specific stressful events	
Did you have an argument or disagreement with anyone since (this time/we spoke) yesterday?	1,061 (9.3)
Since (this time/we spoke) yesterday, did anything happen that you could have argued about but you decided to let pass in order to avoid a disagreement?	1,660 (14.6)
Since (this time/we spoke) yesterday, did anything happen at work or school (other than what you already mentioned) that most people would consider stressful?	1,040 (9.2)
Since (this time/we spoke) yesterday, did anything happen at home (other than what you already mentioned) that most people would consider stressful?	966 (8.5)
Many people experience discrimination on the basis of such things as race, sex, or age. Did anything like this happen to you since (this time/we spoke) yesterday?	56 (0.5)
Since (this time/we spoke) yesterday, did anything happen to a close friend or relative (other than what you've already mentioned) that turned out to be stressful for you?	590 (5.2)
Did anything else happen to you since (this time/we spoke) yesterday that people would consider stressful?	651 (5.7)
Subjective stressfulness ratings	
Not at all stressful	490 (8.1)
Not very stressful	1,381 (22.9)
Somewhat stressful	3,030 (50.3)
Very stressful	1,119 (18.6)
Stressful event resolution	
Resolved	3,273 (60.7)
Unresolved	2,123 (39.3)

Note. $N = 1{,}517$. Endorsement percentages calculated based on observations with complete data.

variable can be modeled as a predictor of positive affect levels and psychopathology 7 years later.

Analyses used Bayesian estimation, which incorporates prior beliefs ("priors") about parameter distributions into final estimates. Priors are updated using observed relationships among variables to obtain a range of possible parameter values termed a posterior distribution. The Bayesian estimator in Mplus performs well with low-frequency categorical dependent variables (e.g., future MDD or anxiety diagnosis; Nguyen, Webb-Vargas, Koning, & Stuart, 2016), as well as categorical dependent variables whose underlying distributions are non-normal (Liang & Yang, 2014). The Bayesian estimator also handles missing data under the missing at random assumption (as in full information maximum likelihood and multiple imputation). Accordingly, all observations with missing data were retained. Please see Table 2 for missing data frequencies.

Model building. Model building proceeded sequentially to justify each premise of the hypotheses, namely (a) associations between daily stress and time experiencing positive affect varied across persons and (b) between-person differences in the within-person association between stress and time experiencing positive affect predicted positive affect and psychopathology 7 years later.

Models 0 and 1: Do within-person associations between daily stress and positive affect vary across persons? We first fit a model (Model 0) in which the within-person level included stress reported on a given day predicting the amount of time positive affect was experienced on the same day. To ensure that estimates

Table 2
Descriptive Statistics

Continuous variables	*M*	Count (%)	*SD* between	*SD* within	ICC	Missing *n* (%)
Daily positive affect	16.22		4.13	2.68	0.70	818 (6.7)
Daily negative affect	0.93		1.22	1.38	0.43	780 (6.4)
Daily leisure time	3.03		1.52	2.11	0.34	785 (6.5)
Mean daily negative affect	0.97		1.41			0 (0)
Proportion of days with stress	0.41		0.26			0 (0)
MIDUS III Positive affect	14.80		4.24			139 (9.2)
Age	57.11		11.30			0 (0)
Categorical variables						
Daily stress		4,587 (40.3)			0.17	763 (6.3)
Past year MDD		148 (9.8)				0 (0)
Past year anxiety		119 (7.8)				0 (0)
Future MDD		144 (9.5%)				0 (0)
Future anxiety		96 (6.3)				0 (0)
Female		847 (55.8)				0 (0)

Note. $N = 1{,}517$. *SD* between = between-person standard deviation; *SD* within = within-person standard deviation; ICC = intraclass correlation; MIDUS III = third wave of the Midlife in the United States study; MDD = major depressive disorder.

of the within-person association between daily stress and time experiencing positive affect were specific to positive affect (e.g., not a reflection of negative emotional stress reactivity), daily negative affect was included as a covariate in predicting the amount of time positive affect was experienced. Daily leisure time was also included as a covariate in predicting the amount of time positive affect was experienced, to ensure that the association between daily stress and positive affect was not an artifact due to diminished time availability on days with stressors. The between-person level of the model included a random intercept for daily positive affect, which was allowed to covary with the following: (a) proportion of days in which a stressor occurred for a given participant, (b) a participant's average level of negative affect, (c) past year MDD and anxiety disorder status, (d) age, and (e) sex. Predictors on the within-person level were person-mean centered, so that random intercepts represented a participant's overall level of positive affect during NSDE II. Fit was evaluated using the posterior predictive p value (PPP), with values above .100 indicating good fit (Cain & Zhang, 2019).

After evaluating Model 0, we added random slopes for the within-person association between daily stress and daily time experiencing positive affect. These random slopes represented between-person differences in the degree to which time experiencing positive affect differed across days with and without stressful events. The random slopes were allowed to covary with all other variables on the between-person level. This model (Model 1) was compared to Model 0 using the deviance information criterion (DIC), with lower values indicating better fit (Cain & Zhang, 2019) and indicating that within-person associations between stress and time experiencing positive affect varied across participants. As a prerequisite for DIC, we tested if posterior distributions were multivariate normal using the Henze-Zirkler test (HZ; Henze & Zirkler, 1990), with p values greater than .05 suggesting DIC is a suitable fit index. Because random effects are assumed normally distributed in MSEM, we also examined the estimated univariate normality of the random intercepts and slopes in Model 1. Random effect skewness values below 1 and kurtosis values below 3 exert minimal effects on model evaluation (Ryu, 2011) and were used as cutoffs for random effect normality.

Models 2 and 3: Do between-person differences in the within-person association between stress and positive affect predict positive affect and emotional disorders 7 years later? We next fit a model (Model 2), which was identical to Model 0 except that all variables on the between-person level (i.e., random intercepts for positive affect, the proportion of days on which a stressor occurred, average daily negative affect, past year MDD, past year anxiety disorder, age, and sex) predicted a MIDUS III outcome. PPP values greater than .100 justified including these variables as predictors of 7-year outcomes. This was conducted with each 7-year outcome (positive affect, MDD diagnosis, and anxiety disorder diagnosis) tested in a separate model (Models 2a, 2b, and 2c, respectively). Binary outcomes (MDD diagnosis and anxiety disorder diagnosis) were modeled using the probit link. Finally, we modified Model 2 by adding random slopes reflecting between-person differences in the within-person association between stress and time spent experiencing positive affect and included these random slopes as additional predictors of MIDUS III outcomes. For the prediction of future positive affect, we examined change in the between-person R^2 between this model (Model 3a) and the model without random slopes (Model 2a). For the prediction of MDD (Model 3b) and anxiety disorder diagnosis (Model 3c), we tested improvement in fit relative to Models 2b and 2c using the pseudo-R^2 index developed by McKelvey and Zavoina (1975) for binary outcomes. An increase in R^2 or pseudo-R^2 indicated that a greater percentage of variance in the 7-year outcome had been explained, justifying the inclusion of the random slopes as predictors of mental health outcomes.

Final models. If each aspect of complexity was supported, we retained Model 3. Thus, the within-person level included daily stress, daily negative affect, and daily leisure time predicting the amount of time positive affect was experienced on the same day. Predictors on the between-person level included the proportion of days on which a stressor occurred, average daily negative affect, past year MDD and anxiety disorder status, age, sex, random intercepts representing overall levels of positive affect, and random slopes representing person-specific associations between daily stress and time spent experiencing positive affect. Outcome variables on the between-person level, tested separately, included positive affect, MDD diagnosis, and anxiety disorder diagnosis 7 years later. These models tested whether susceptibility to reduced time experiencing positive affect on stressful event days predicted future positive affect and emotional disorders above and beyond stress exposure, dispositional affect, past year emotional disorders, age, and sex. Please see Figure 1 for a diagram of Model 3.

For all structural paths, we computed unstandardized regression parameters representing the median of posterior distribution, as well as 95% credible intervals (CIs) surrounding the estimate. Intervals that do not include zero can be considered statistically significant. As a standardized measure of effect size, we computed change in between-person R^2 (or pseudo-R^2) for the association between reduced time experiencing positive affect on stressful event days and 7-year outcomes.

Priors for regression coefficients were normal with means of zero and variances of $\left(\frac{\sigma'^2_Y}{\sigma'^2_X}\right)$, where σ'^2_Y was the variance of the predicted variable and σ'^2_X was the variance of the predictor variable. For binary predictors, σ'^2_X was replaced with 1. These priors express the belief that it is unlikely that a one standard deviation difference in a continuous predictor (or a one-unit difference in a binary predictor) is associated with anything beyond a 1 *SD* difference in a predicted variable. These priors reduce risk of multiple testing errors by shrinking parameter estimates toward zero (Lemoine, 2019). Priors for means, probit thresholds, variances, and covariances were noninformative.[1] Models used 500,000 Markov Chain Monte Carlo iterations with the first half discarded as a burn-in period and estimates saved from every 100th iteration, resulting in 2,500 saved iterations.

[1] Priors for means were normal with means of 0 and variances of infinity; priors for probit thresholds were normal with means of 0 and variances of 5; priors for residual variances were inverse-gamma with shape of −1 and scale of 0 (Asparouhov & Muthén, 2010). Priors for variance-covariance matrices were inverse-Wishart with scale and degrees of freedom equal to the identity and order of the matrix, respectively (Chen, 2011). Re-specification with different priors did not affect results. Please see the online supplementary materials for a full list of priors.

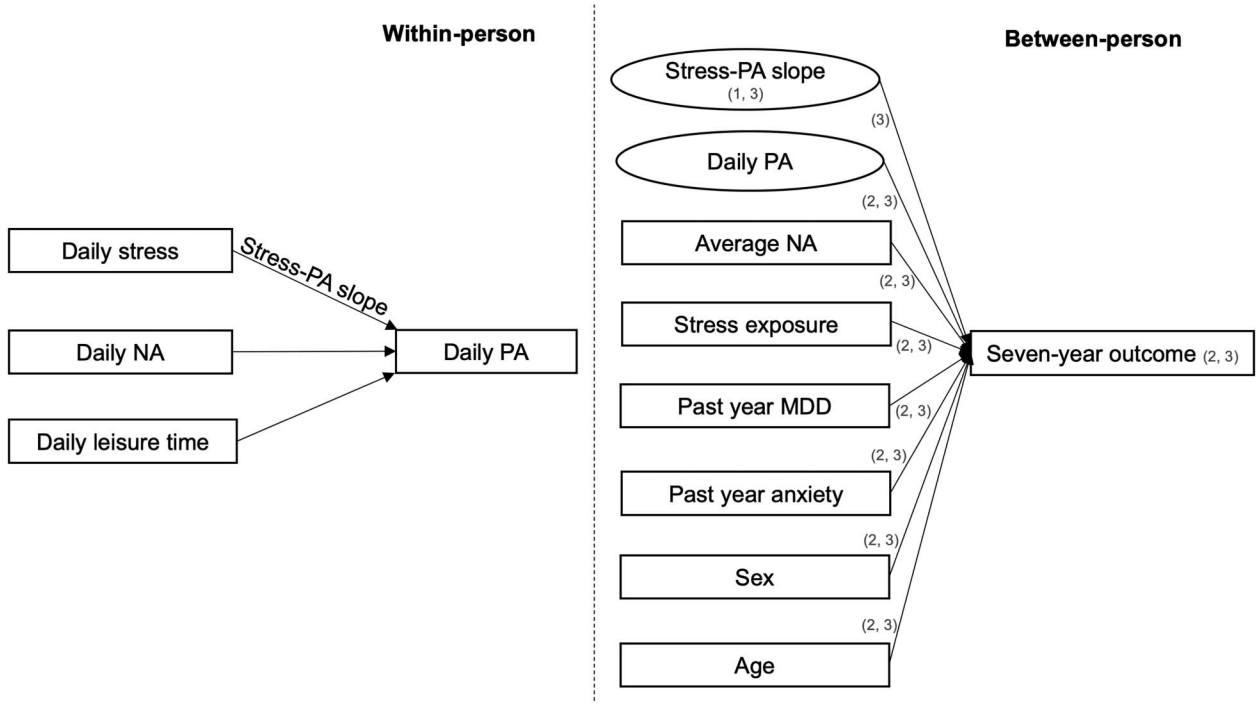

Figure 1. Path diagram of Model 3. Numbers in parentheses indicate variables and regression paths added in sequential models (1, 2, or 3); unnumbered variables and regression paths were included in all models (0, 1, 2, and 3). Daily PA on the within-person level represents the amount of time a participant experienced positive affect on a given day, which was predicted by the presence versus absence of a stressful event (daily stress), as well as negative affect (daily NA) and time spent on leisure activities (daily leisure time) on the same day. Daily PA on the between-person level is a random intercept representing overall positive affect. Stress-PA slope represents the strength of the association between daily stressful events and daily time experiencing positive affect, which varied across participants. Average NA is the average negative affect reported during the daily diary study. Stress exposure is the proportion of days on which a participant experienced a stressor during the daily diary study. Past year major depressive disorder (MDD) and anxiety represent diagnosis of MDD and anxiety disorders, respectively, before the daily diary study. Seven-year outcomes (trait positive affect, MDD diagnosis, and anxiety disorder diagnosis) were regressed on other variables on the between-person level in separate models. Means, intercepts, probit thresholds, variances, covariances, and residuals are not shown.

Results

Preliminary Analyses

Descriptive statistics are reported in Table 2. Continuous dependent variables were approximately normally distributed (daily positive affect skewness = −0.66, kurtosis = 0.43; MIDUS III positive affect skewness = −0.65, kurtosis = 0.51). Posterior distributions were multivariate normal for Models 0 (HZ = 1.000, p = .814) and 1 (HZ = 1.000, p = 1), indicating suitability of DIC. Fit was good for Model 0, in which daily stress, daily negative affect, and daily leisure time were modeled as predictors of the amount of time positive affect was experienced on the same day (PPP = .261, DIC = 170,232). Adding random slopes for the association between stress and time experiencing positive affect in Model 1 improved fit (DIC = 170,038, ΔDIC = −194). The difference in within-person R^2 between Model 0 (.143) and Model 1 (.165) was .022, indicating that between-person differences in the within-person association between stressful events and time spent experiencing positive affect explained approximately 2% of variance in time spent experiencing positive affect. Estimated distributions for random intercepts (skewness = −0.63, kurtosis = 0.46) and slopes (skewness = 0.40, kurtosis = 1.30) were within acceptable normality limits.

Fit was also good for Model 2, in which random intercepts for daily positive affect, average daily negative affect, the proportion of days on which a stressor occurred, past year MDD and anxiety disorder diagnosis, age, and sex were modeled as predictors of positive affect (Model 2a: PPP = .283, R^2_{between} = .312), MDD (Model 2b: PPP = .263, R^2_{between} = .189), and anxiety disorder diagnosis (Model 2c: PPP = .259, R^2_{between} = .249) 7 years later. Adding random slopes for the association between daily stress and amount of time experiencing positive affect as predictors of 7-year outcomes improved fit for the prediction of positive affect (Model 3a: R^2_{between} = .346; $\Delta R^2_{\text{between}}$ = .034), MDD (Model 3b: R^2_{between} = .252; $\Delta R^2_{\text{between}}$ = .063), and anxiety disorder diagnosis (Model 3c: R^2_{between} = .467; $\Delta R^2_{\text{between}}$ = .218) 7 years later. Therefore, we retained Model 3 for each outcome.

Final Model Results

Please see Table 3 for complete results from Models 3a, 3b, and 3c. On the within-person level for all models, negative affect was negatively associated with time experiencing positive affect, and leisure time was positively associated with time experiencing positive affect, indicating that participants reported less time experiencing positive affect on days with heightened negative affect and more time experiencing positive affect when they spent more time on leisure activities. Importantly, stressful events were negatively associated with time experiencing positive affect, indicating that participants reported less time experiencing positive affect on days when they reported stressors. There was also significant variance in random slopes for daily stress predicting amount of time experiencing positive affect, indicating that participants varied in the extent to which their time experiencing positive affect differed on days with stressors compared to days without stressors.

In the between-person level of Model 3a, positive affect 7 years later was significantly predicted by random intercepts representing overall positive affect ($\beta = 0.549$, 95% CI [0.482, 0.625]), average negative affect ($\beta = -0.280$, 95% CI [−0.527, −0.075]), and past year MDD ($\beta = -1.356$, 95% CI [−2.112, −0.565]), indicating that greater overall positive affect, less average negative affect, and absence of MDD were associated with greater positive affect in the future. Importantly, positive affect 7 years later was also significantly predicted by the random slope representing the difference in time spent experiencing positive affect on days with versus without stressors ($\beta = 0.870$, 95% CI [0.279, 1.691], $\Delta R^2_{\text{between}} = .034$). The positive sign of this association indicates that, as hypothesized, individuals who reported especially diminished proportions of the day experiencing positive affect on days when they experienced stressors had lower positive affect 7 years later.

In Models 3b and 3c, MDD and anxiety disorders 7 years later were significantly predicted by random intercepts for daily positive affect (MDD: $\beta = -0.046$, 95% CI [−0.083, −0.014]; anxiety: $\beta = -0.068$, 95% CI [−0.148, −0.023]), average levels of daily negative affect (MDD: $\beta = 0.146$, 95% CI [0.059, 0.268]; anxiety: $\beta = 0.254$, 95% CI [0.121, 0.515]), and past year diagnosis of the same disorder (MDD predicting MDD: $\beta = 0.723$, 95% CI [0.426, 1.011]; anxiety predicting anxiety: $\beta = 1.229$, 95% CI [0.811, 1.835]). Thus, future psychopathology was predicted by lower overall positive affect, higher average negative affect, and past year psychopathology. Importantly, the random slope representing the difference in time spent experiencing positive affect on days with versus without stressors was significantly negatively associated with future MDD diagnosis ($\beta = -0.322$, 95% CI [−0.793, −0.039], $\Delta R^2_{\text{between}} = .063$) and future anxiety disorder diagnosis 7 years later ($\beta = -0.740$, 95% CI [−1.768, −0.264], $\Delta R^2_{\text{between}} = .218$). These negative associations indicate that, as hypothesized, individuals reporting especially reduced proportions of the day experiencing positive affect when they experienced stressors were more likely to experience MDD and GAD or PD 7 years later.[2]

Discussion

Results suggested that susceptibility to reduced time experiencing positive affect on days with stressful events predicted lower positive affect, depression, and anxiety disorders 7 years later. This study extends research on positive emotions' role in mental health by examining long-term correlates of the within-person association between stress and positive emotions. Because analyses controlled for age, sex, leisure time, average levels of stress and emotion, and past year psychopathology, as well as daily negative affect's associations with stress and time spent experiencing positive affect, results suggest a unique role for diminished positive emotions in the context of stress in psychopathology, beyond negative emotional stress reactivity.

The association between reduced time experiencing positive affect on days with stress and future positive affect is consistent with "upward spiral" accounts suggesting that positive emotions beget future positive emotions through reciprocal links with cognitive, behavioral, and social resources (Garland et al., 2010). Whereas prior research has documented beneficial effects of heightened positive emotions (e.g., Fredrickson & Joiner, 2002), the present study suggests that reduced time experiencing positive emotions on days with stressors could give way to downward spirals in mental health. These findings also extend research testing positive emotions as a buffer against the adverse effects of stress (Folkman, 2008), instead suggesting that positive emotions are a within-person negative correlate of stress, and individual differences in this within-person association have implications for mental health. Emotion theories (Fredrickson, 2001; Lang & Bradley, 2013) point to several possible mechanisms for the association between lowered time experiencing positive affect on days with stress and lower future positive affect, including reductions in positive reappraisal, goal-directed behavior, and relationship quality. These variables have both direct (e.g., Zainal & Newman, 2019) and stress-buffering (e.g., Folkman, 2008) associations with mental health. Further research with additional repeated measures of stress, positive emotions, and positive emotions' putative concomitants can identify mechanisms by which lowered positive affect during stress relates to future positive affect.

[2] We conducted supplementary analyses examining if subjective stressfulness was as important to our findings as objectively stressful events. When objectively stressful events were required to be rated by participants as at least "somewhat stressful" to be considered stressors, only the association between reduced time experiencing positive affect on days with stressors and future anxiety disorders remained significant, with credibility intervals for the prediction of future positive affect and MDD narrowly including zero. However, all hypothesized associations in Model 3 were significant when we lowered the cutoff and only events rated as "not at all stressful" were considered nonstressors (i.e., events had to be at least "not very stressful" to be considered stressors; see the online supplementary materials). Because these differential findings might have been due to power differences (i.e., more or less data on within-person correlates of stressors dependent on the cutoff we used), we conducted further analyses to determine if ratings of subjective stressfulness might be relevant. For these analyses, we examined dimensional ratings of subjective stressfulness (from *not at all* to *very stressful*) and ratings of event resolution (unresolved vs. resolved) predicting time experiencing positive affect on days in which participants endorsed at least one objectively stressful event. Interestingly, neither the within-person association between events' subjective stressfulness and time experiencing positive affect nor the within-person association between events' resolution and time experiencing positive affect were significantly related to any 7-year outcomes (see the online supplementary materials). Thus, reduced time experiencing positive affect in the context of *any* potentially stressful event, rather than events perceived as more or less stressful, was most consistently related to future mental health outcomes.

Table 3
Results From Multilevel Structural Equation Models

	Model 3a				Model 3b				Model 3c			
	Daily positive affect		Future positive affect		Daily positive affect		Future MDD		Daily positive affect		Future anxiety	
Model	Est.	95% interval	Est.	95% interval	Est.	95% interval	Est.	95% interval	Est.	95% interval	Est.	95% interval
Fixed (within)												
Daily stress	**−0.636**	**[−0.762, −0.513]**			**−0.630**	**[−0.748, −0.504]**			**−0.634**	**[−0.751, −0.510]**		
Daily negative affect	**−0.705**	**[−0.742, −0.668]**			**−0.705**	**[−0.742, −0.668]**			**−0.705**	**[−0.741, −0.669]**		
Daily leisure time	**0.079**	**[0.056, 0.102]**			**0.079**	**[0.056, 0.102]**			**0.079**	**[0.057, 0.102]**		
Fixed (between)												
PA intercept			**0.549**	**[0.482, 0.625]**			**−0.046**	**[−0.083, −0.014]**			**−0.068**	**[−0.148, −0.023]**
Stress-PA slope			**0.870**	**[0.279, 1.691]**			**−0.322**	**[−0.793, −0.039]**			**−0.740**	**[−1.768, −0.264]**
Stress exposure			0.313	[−0.614, 1.236]			0.305	[−0.150, 0.738]			−0.291	[−1.006, 0.347]
Mean negative affect			**−0.280**	**[−0.527, −0.075]**			**0.146**	**[0.059, 0.268]**			**0.254**	**[0.121, 0.515]**
Past year MDD			**−1.356**	**[−2.112, −0.565]**			**0.723**	**[0.426, 1.011]**			0.218	[−0.261, 0.641]
Past year anxiety			−0.195	[−1.012, 0.610]			0.263	[−0.070, 0.593]			**1.229**	**[0.811, 1.835]**
Sex			−0.385	[−0.882, 0.041]			−0.079	[−0.302, 0.163]			−0.119	[−0.449, 0.268]
Age			−0.016	[−0.037, 0.004]			−0.006	[−0.016, 0.004]			−0.016	[−0.033, 0.000]
Random (between)												
PA intercept	**17.345**	**[16.076, 18.681]**			**17.314**	**[16.121, 18.682]**			**17.320**	**[16.122, 18.683]**		
Stress-PA slope	**0.868**	**[0.575, 1.223]**			**0.864**	**[0.561, 1.238]**			**0.855**	**[0.569, 1.220]**		

Note. N = 1,517. PA intercept = overall daily positive affect; Stress-PA slope = within-person association between stress and time experiencing positive affect; MDD = major depressive disorder; Anxiety = generalized anxiety disorder or panic disorder. Fixed effect estimates are regression coefficients. Random effect estimates are variances. Bold indicates that credibility interval excludes zero.

Susceptibility to reduced time experiencing positive affect on days with stressors also predicted future MDD and anxiety disorders. These findings contrast with previous theorizing that low positive affect is unique to MDD (Clark & Watson, 1991), instead building on recent data to suggest that positive affect impairments predict both depression and anxiety (e.g., Khazanov & Ruscio, 2016). The results provide a more fine-grained illustration of positive emotion impairments in depression and anxiety than existing research. Meta-analyses have linked lower overall positive affect (Khazanov & Ruscio, 2016) and greater instability of positive affect (Houben et al., 2015) to depression and anxiety, yet the relevant environmental contexts for these positive affect characteristics have not been identified. Difficulty sustaining positive affect in the context of daily stress may explain the diminished and labile positive emotional experiences in emotional disorders. Given potential links between low positive affect and perseverative cognition and avoidance (e.g., Newman et al., 2019), lowered positive affect in the context of stress could instantiate a cascade of maladaptive processes leading to psychopathology. Additional research with repeated measures of psychopathological constructs would elucidate pathways linking within-person stress-positive emotion associations to emotional disorders.

Efforts at preventing and treating emotional disorders may benefit by targeting positive emotions in the face of stress. Positive emotion interventions have been found to increase positive emotion and decrease distress among persons with emotional disorders (Craske et al., 2019) and persons facing major medical stress (e.g., Moskowitz et al., 2017). Although these results are promising, it is unclear whether these interventions target positive affect in general or resilience to lowered positive affect during stress. Given the ubiquity of daily stressors, identifying efficient and effective interventions to maintain positive affect in the face of stress (e.g., through mobile technology; LaFreniere & Newman, 2019) could facilitate prevention efforts. For example, it may be possible to target positive emotions during stress using continuous monitoring of stressful events and delivery of positive emotion maintenance exercises (e.g., positive reappraisal, benefit-finding) when stressful events are reported. Repeated practice of these techniques may build skills for maintaining positive emotion during stress.

Several limitations of this study should be noted. First, because stress and affect were assessed once per day during NSDE II, we could not examine lagged within-day associations between stress and affect. Thus, the within-person association between stress and positive affect could have reflected a combination of low positive affect in reaction to stress and increased probability of stress on days with low positive affect (i.e., stress generation). In addition, because the measure of affect asked about the amount of time positive affect was experienced during the day, the within-person association between stress and positive affect could have been partly driven by reduced time available to experience positive emotions on days with stressors. We attempted to mitigate these limitations by modeling overall stress exposure as a covariate in predicting 7-year outcomes and modeling daily leisure time as a covariate in predicting daily positive affect. However, research with more frequent assessment of stressors and emotion states would clarify the time course of the association between stress and positive affect. There was also a relatively low rate of psychopathology during MIDUS III, and although analyses controlled for past year psychopathology, lifetime measures of psychopathology

during NSDE II were unavailable. Relatedly, the study lacked assessments of other anxiety disorders beyond GAD and PD. The Bayesian estimator in Mplus performs well when modeling categorical variables with low probability outcomes (Nguyen et al., 2016), and we do not expect that power was adversely affected by the low rate of psychopathology. Nonetheless, replication in an at-risk sample with assessment of multiple disorders would improve generalizability and allow examination of the associations between lowered positive affect in the context of daily stress and specific disorders.

The present study suggests that susceptibility to reduced time experiencing positive emotions on days with stressful events predicts poor mental health outcomes across 7 years, including low positive affect, MDD, and anxiety disorders. Future basic research should use intensive longitudinal methods to understand the intricate links between stress, positive emotions, and psychopathology. Applied research should seek to improve positive emotion regulation in the face of pervasive daily stressors. Identifying stress-related emotional processes and how to target them in interventions may enhance resilience to psychopathology.

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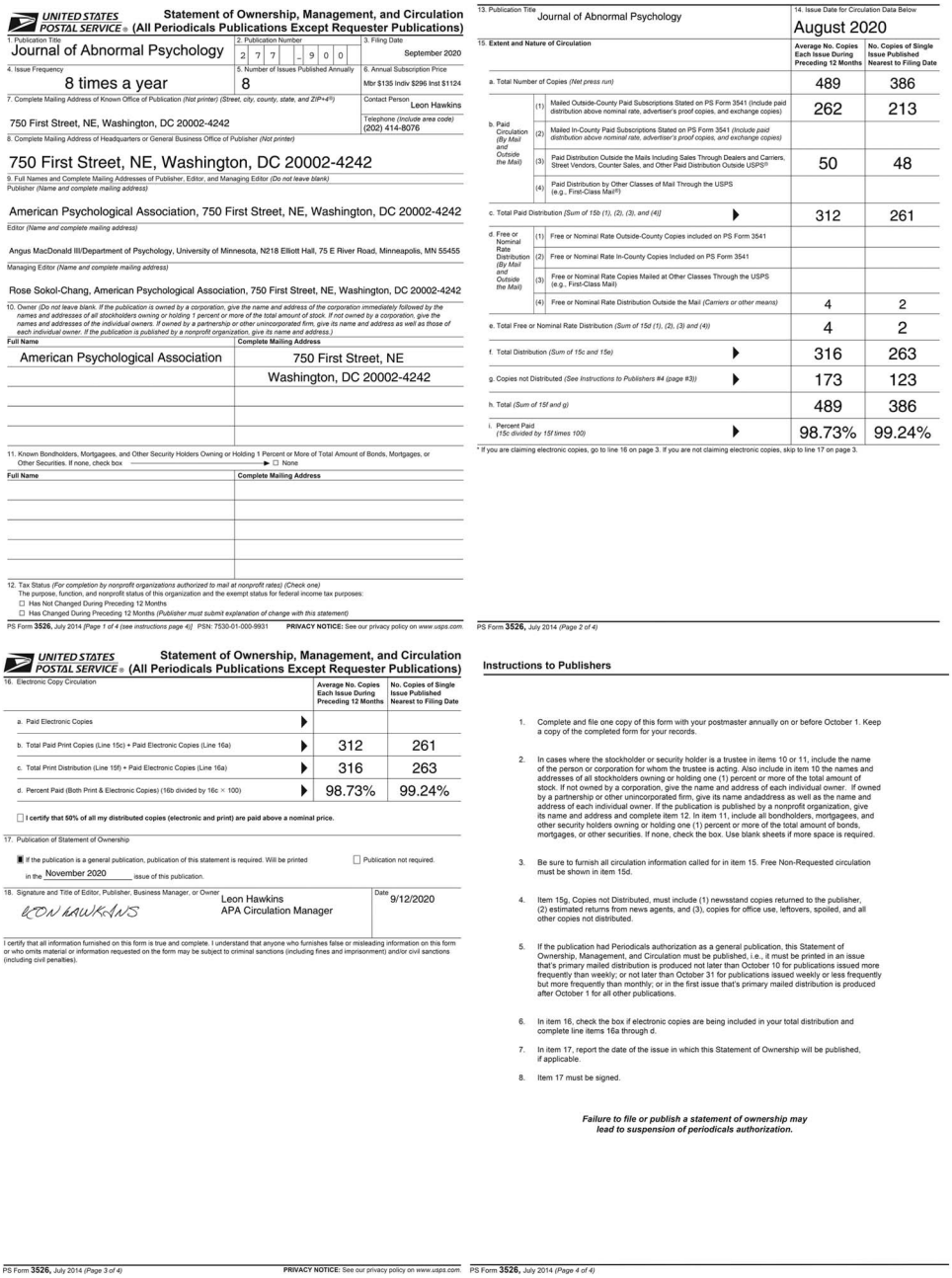

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